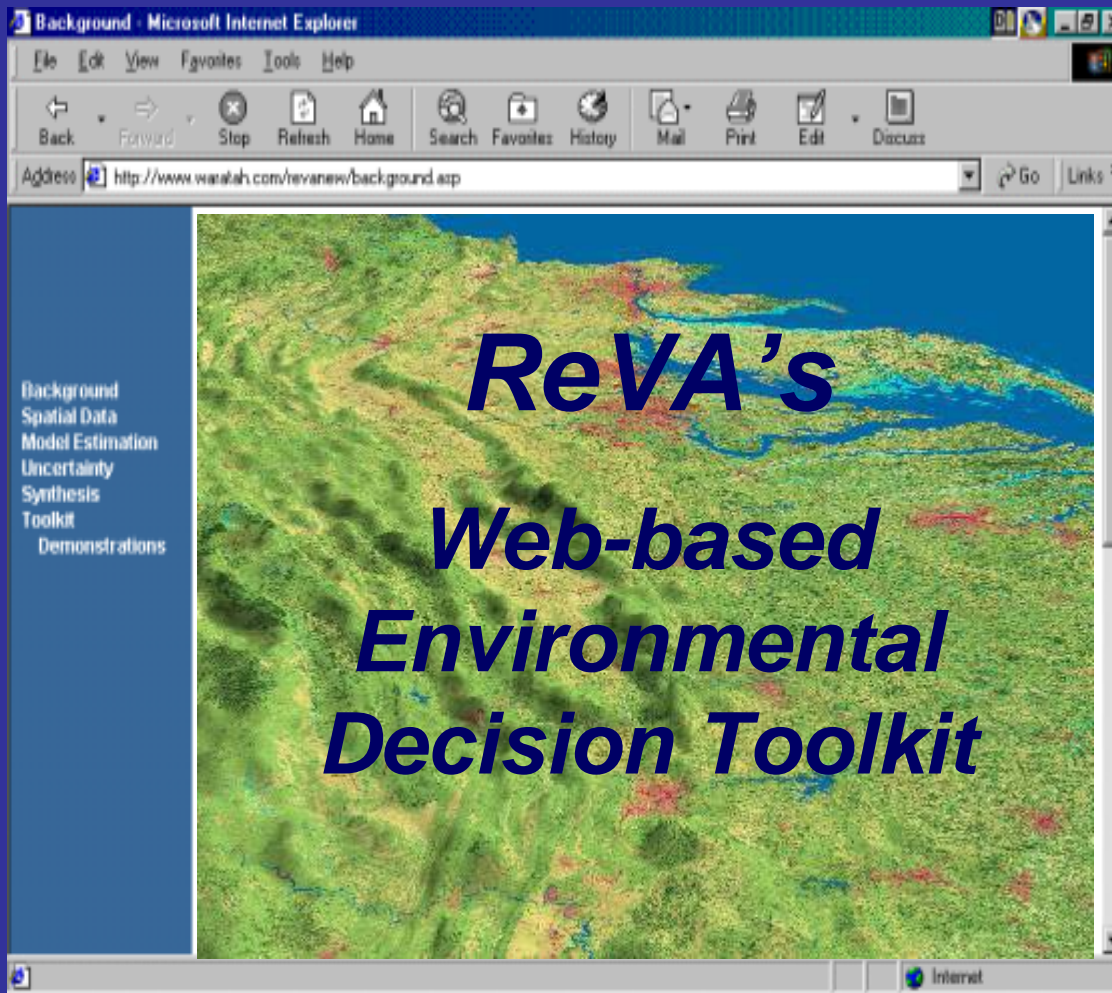


Synthesizing Multiple Environmental Indicators: ReVA's Environmental Decision Toolkit

Elizabeth R. Smith, US EPA, Office of Research
and Development



Facilitating Environmental Decision-making

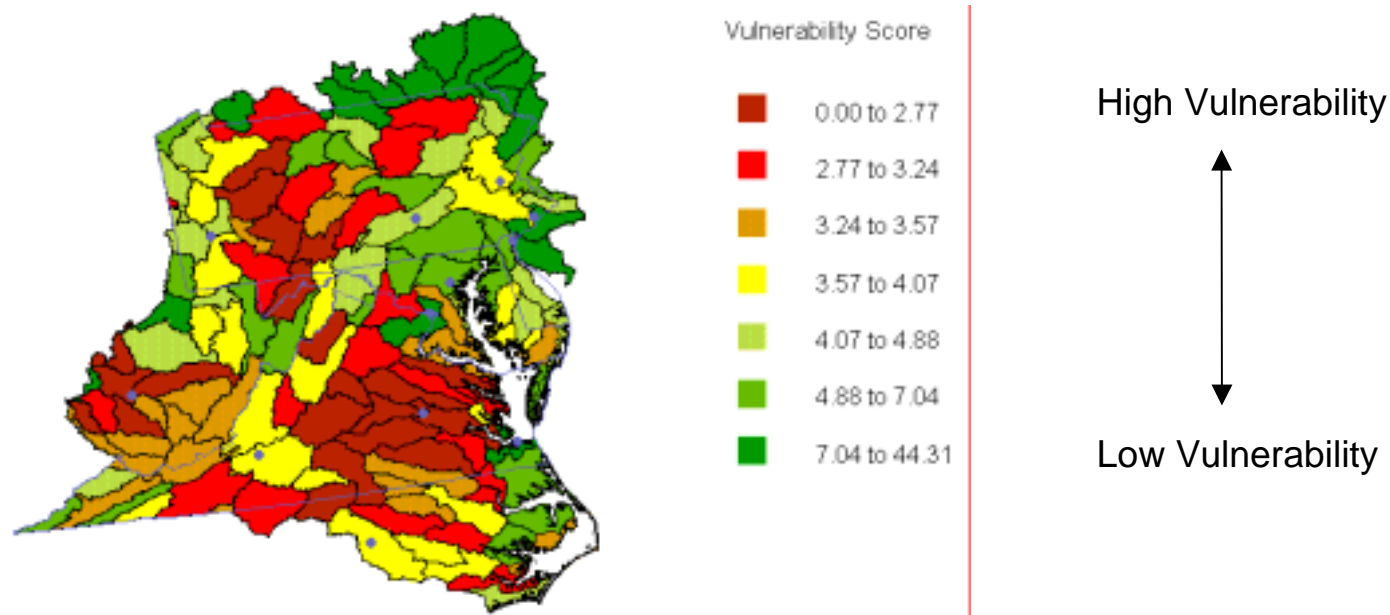


- Prototype version available currently to client partners
- Public version to be deployed in late FY 04
- Portable – can be adapted to any region, any scale

Turning Spatial Data into Information for Decision Makers

- Web-based integration and visualization
- Data diagnostics and data preparation
- Integration of data in selectable subgroups
- Weighting in support of multi-criteria decision making
- Data access (summarized by reporting unit)

ReVA synthesizes environmental data and model results to inform decision-making

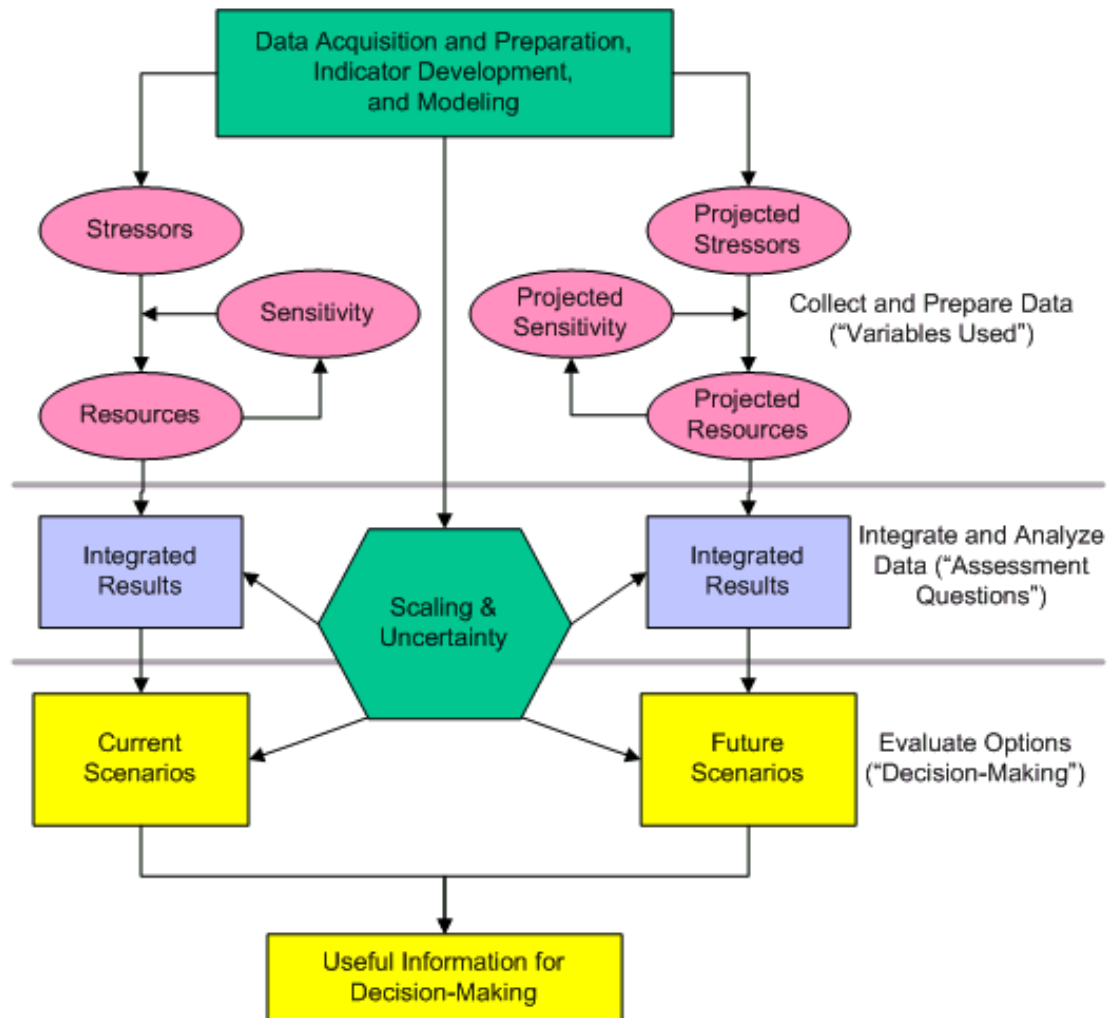


Data on resource condition and sensitivity

+

Modeled distributions of stresses

Environmental Decision Toolkit



This guided tour:

How are Decisions Made to Reduce Risk for Vulnerable Ecosystems?

- **Multiple Criteria**

Stakeholder Input, Politics, Economics, Feasibility, Scientific Understanding

- **Evaluation of Trade-offs**

Costs/ Benefits of Alternatives



What Makes an Ecosystem “Vulnerable”?

- **Condition**

Pristine, Good, Stressed, Degraded

- **Sustainability**

f (ecosystem sensitivity, resiliency; stressors affecting)

- **Value to Society**

Aesthetics, Economic Opportunities, Goods and Services

What Drives Risk Management Decisions?

- **Feasibility, Clear Options, Economics**

What works where?, Range of method applicability

Multiple Decision-Criteria Require Multiple Integration Methods

- **Ranking Methods (*Condition*)**

Where are the best/worst places in region?

- **Distance from Reference Point (*Sustainability*)**

Where is there risk of major change?

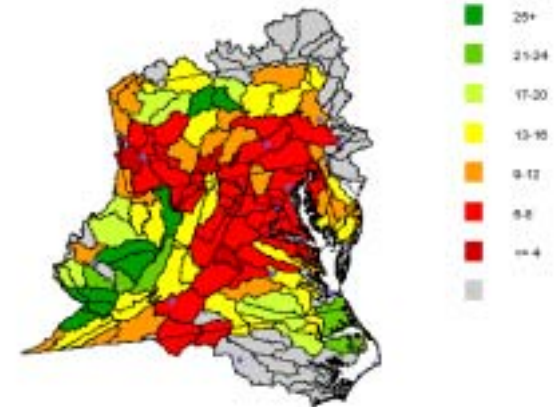
- **Overlay of stressors/resources (*Value*)**

What/where are the most vulnerable resources given future stressor distributions?

- **Grouping of Like Units (*Feasibility*)**

Where are the priorities for regional risk reduction activities?

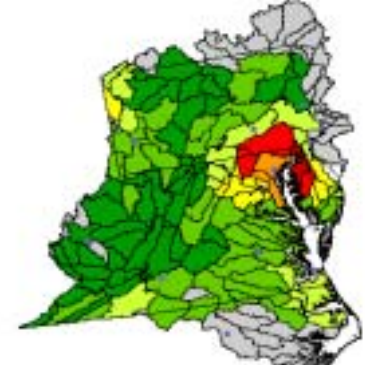
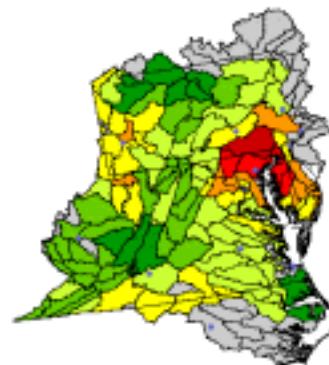
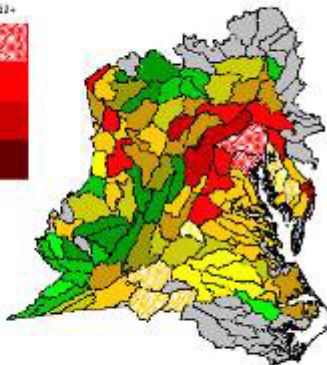
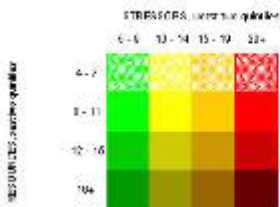
Best Quintile Counts



Stressor-Resource Overlay

Radar Area Summary

State Space



Integration Methods

- **Best/Worst Quintiles** – number of variables in best/worst quantile
- **Simple Sum** – add normalized values of all variables
- **Principal Component Analysis** – transform variables then calculate Euclidean distance from reference
- **State Space Analysis** – Mahalanobis distance from reference
- **Criticality Analysis** – fuzzy distance from hypothetical “natural” state
- **Analytical Hierarchy Process** – multi-criteria tool that uses decision-maker preferences in the calculations
- **Cluster Analysis** – partitioning methods to group units
- **Self-organizing Map** – self-organizing map to group units
- **Stressor-Resource Overlay** – high-stress values with high resource values
- **Stressor-Resource Matrix** – ranks stressors and resources using correlation coefficients

Data Issues: Effects on Integration Methods

Method	Discontinuity	Skewness	Imbalance	Interdependency
Quantiles	Not sensitive	Not sensitive	Sensitive	Sensitive
Sum	Not sensitive	Not sensitive	Sensitive	Sensitive
AHP	Not sensitive	Not sensitive	Sensitive	Sensitive
PCA	Sensitive	Sensitive	Not sensitive	Not sensitive
State Space	Sensitive	Sensitive	Not sensitive	Not sensitive
Criticality	Not sensitive	Not sensitive	Sensitive	Sensitive
Overlay	Not sensitive	Not sensitive	Not sensitive	Not sensitive
Cluster	Not sensitive	Sensitive	Sensitive	Sensitive
SOM	No Problem	Sensitive	Sensitive	Sensitive
Matrix	Sensitive	Sensitive	Sensitive	Not Sensitive

These results directly transferable to any region, any geographic scale

Data Issues

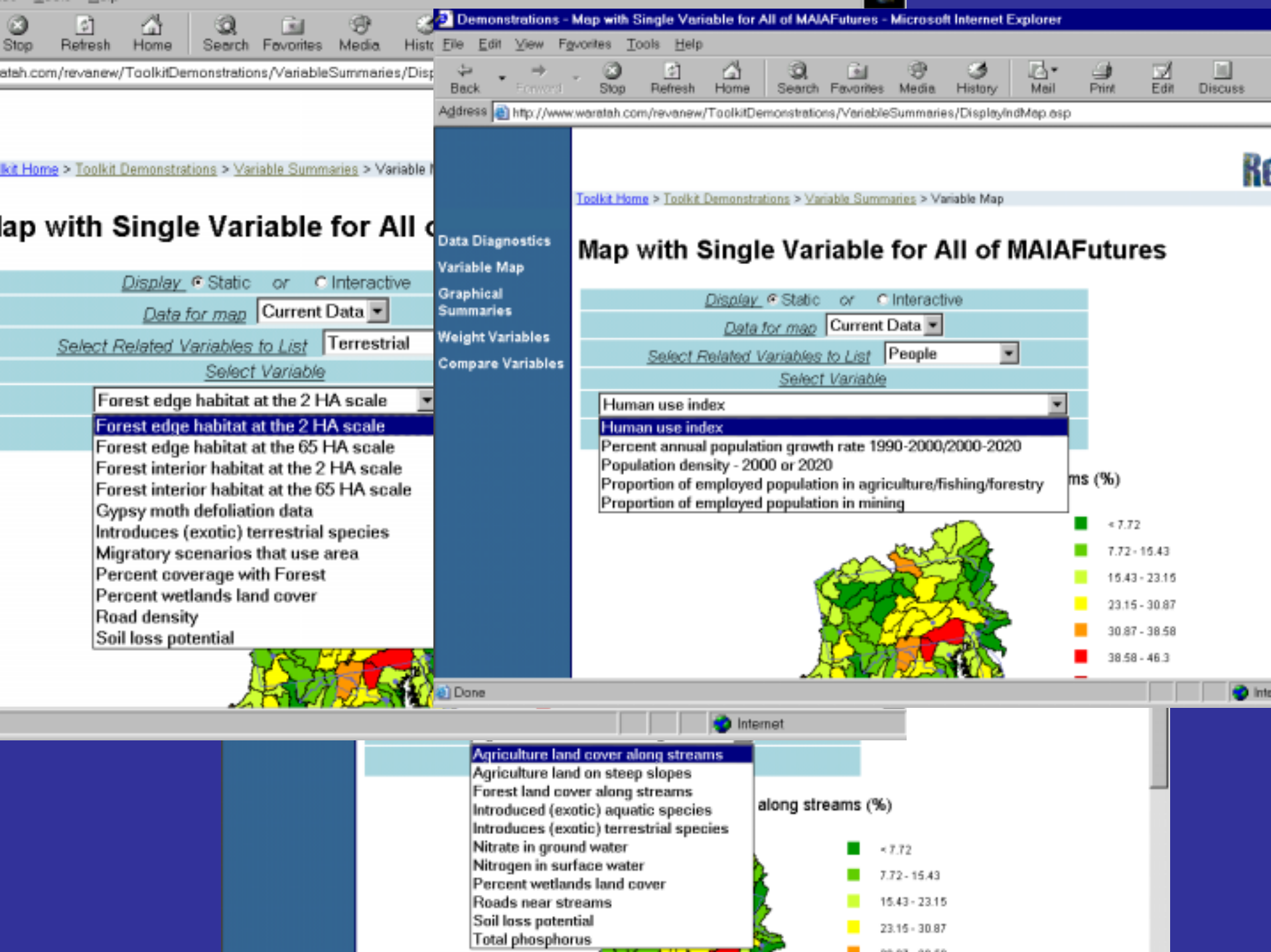
Integration
Methods

Integration Methods

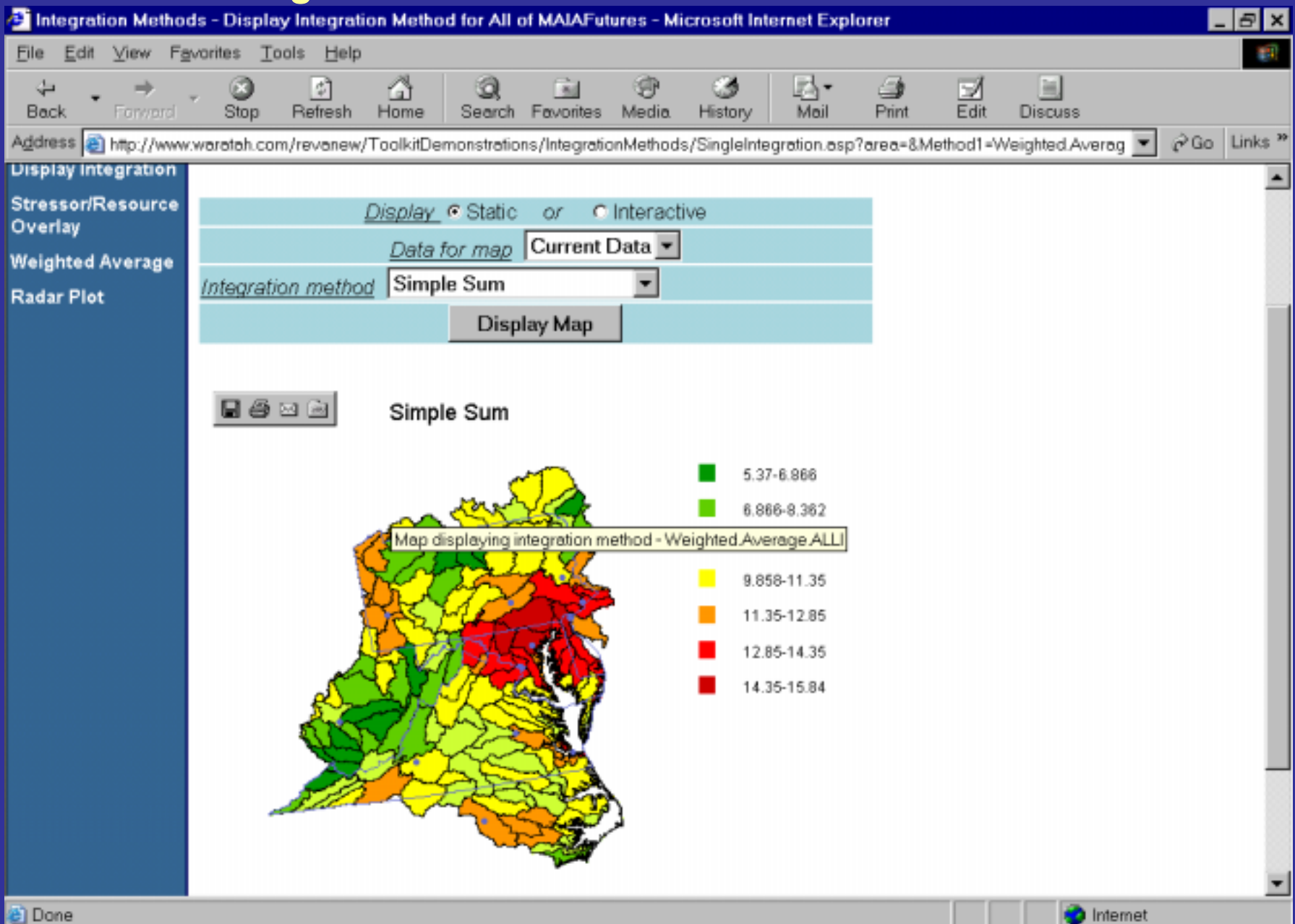
One purpose of ReVA is to develop and evaluate integration methods. Based on a preliminary analysis of integration methods performed on a complete suite of variables in the Mid-Atlantic region, we have classified the methods into several different groups listed below. The methods that rank condition appear to have similar results, however this may not be the case in other regions or for subsets of data. It is recommended a suite of integration methods be employed to explore different aspects of environmental condition and vulnerability.

The integration methods can be organized into several different groups:

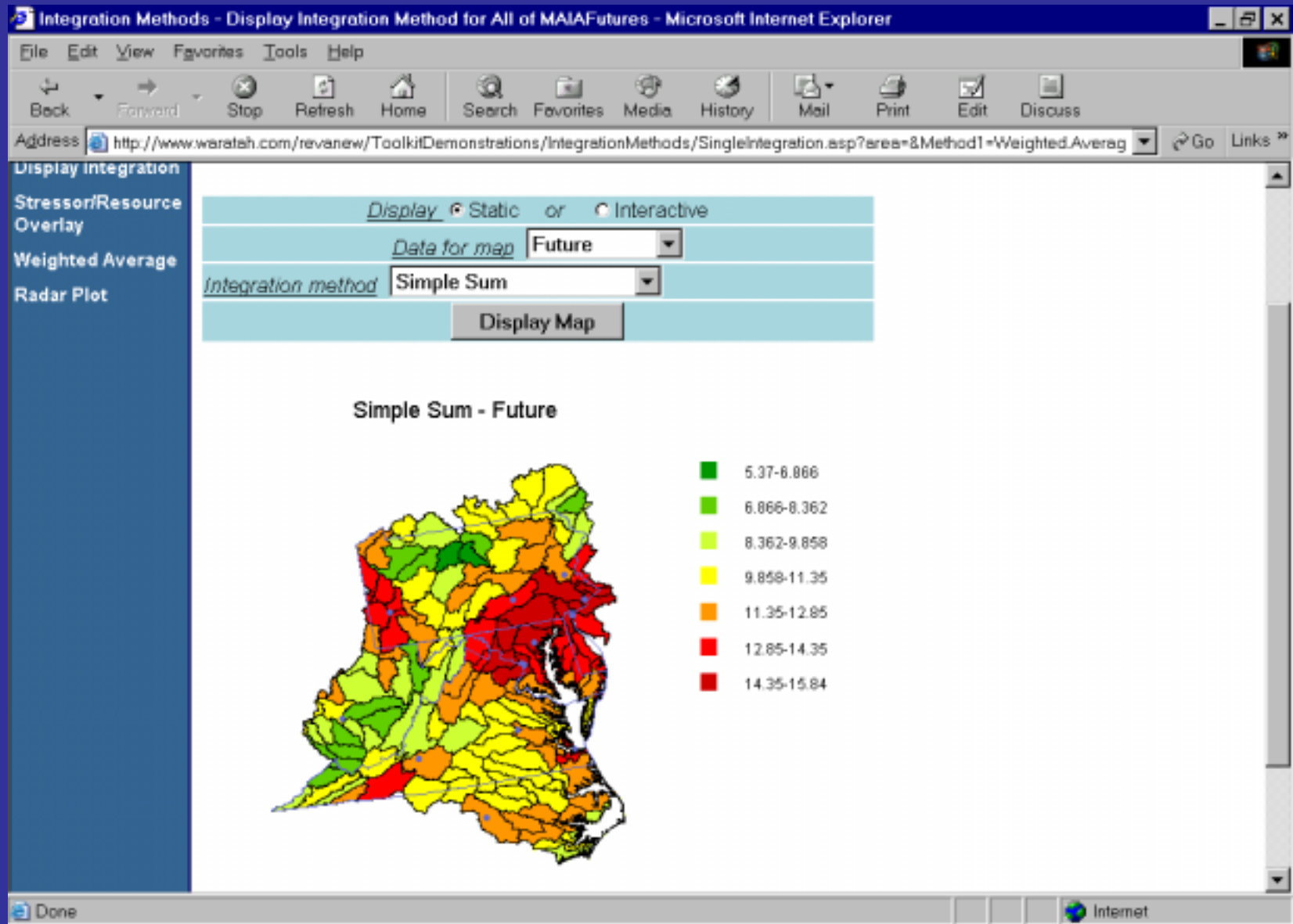
- Methods that rank by condition - these all give similar maps:
 - [Quintiles - Best/Worst](#)
 - [Simple Sum](#)
 - [Analytical Hierarchy Process \(AHP\)](#)
- Methods that rank by distance to some reference condition
 - [State-Space Analysis](#)
 - [Principle Component Analysis \(PCA\)](#)
 - [Criticality Analysis](#)
- Methods that rank by vulnerabilities
 - [Stressor/resource overlay](#)
 - [Stressor/resource matrix](#)
- Methods that group by similar characteristics
 - [Cluster analysis](#)
 - [Self-organizing maps \(SOM\)](#)
- Visualizations and trade-offs
 - [User-specified weightings](#)
 - [Radar plots](#)



What is the Spatial Pattern of Environmental Condition Across the Mid-Atlantic Region?



How will Environmental Conditions Change Across the Region in 2020?



Which Watersheds are in the Worst Condition Now and in 2020?

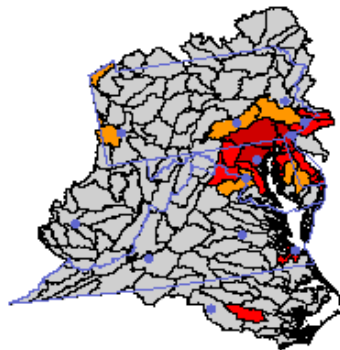
Comparing Worst Quintile vs. Worst Quintile - Microsoft Internet Explorer

File Edit View Favorites Tools Help

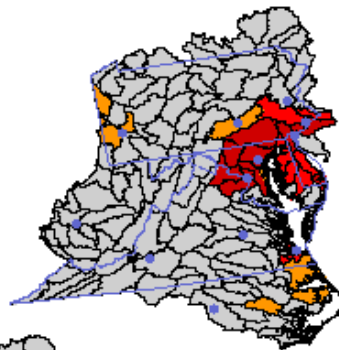
Comparing Quintile Counts-Worst to Quintile Counts-Worst - Future



Quintile Counts-Worst

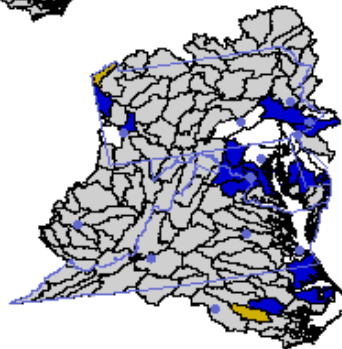


Quintile Counts-Worst - Future



Watershed Summary
Method Comparison

- LHS better
- Same
- RHS better



Difference Map

Close Window

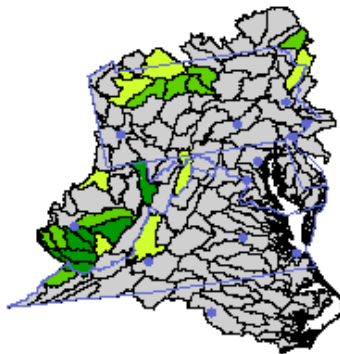
Which Watersheds are in the Best Condition Now and in 2020?

Comparing Best.Quintile vs. Best.Quintile - Microsoft Internet Explorer

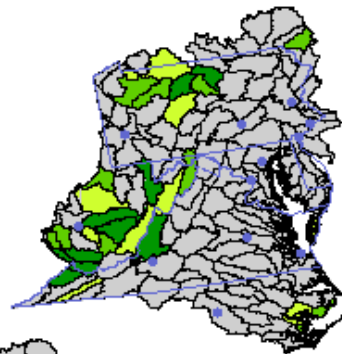
File Edit View Favorites Tools Help

Comparing Quintile Counts-Best to Quintile Counts-Best - Future

Quintile Counts-Best

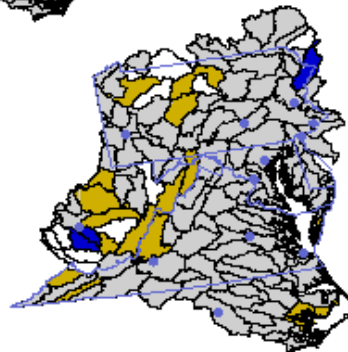


Quintile Counts-Best - Future



Watershed Summary
Method Comparison

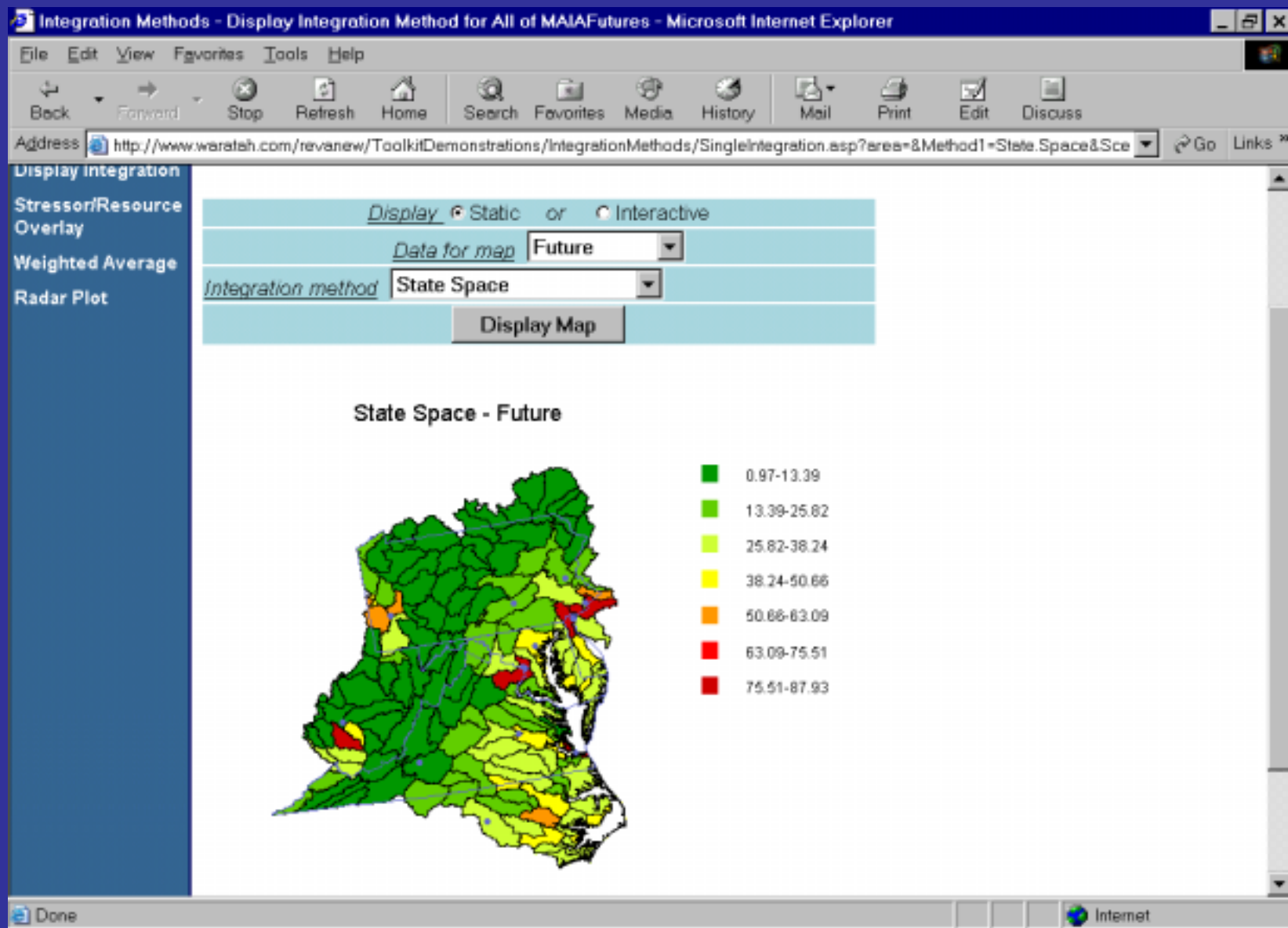
- LHS better
- Same
- RHS better



Difference Map

Close Window

Which Watersheds Will Be the Most Vulnerable in the Future?



How will the Pattern of Vulnerable Watersheds Change From Now to 2020?

Comparing Stressor.Resource vs. Stressor.Resource - Microsoft Internet Explorer

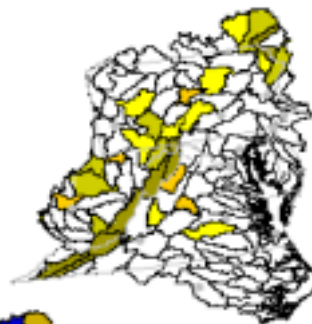
File Edit View Favorites Tools Help

Comparing Stress-Resource Overlay to Stress-Resource Overlay - Future

Stress-Resource Overlay

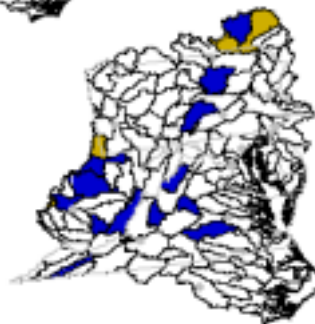


Stress-Resource Overlay - Future



Watershed Summary
Method Comparison

- LHS better
- Same
- RHS better



Difference Map

Close Window

How Will the Pattern of Watersheds Vulnerable to Irreversible Change Change From Now to 2020?

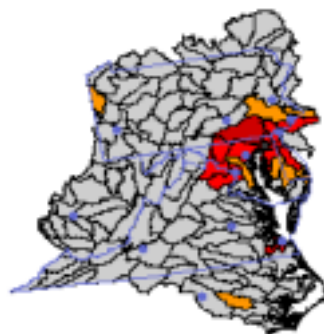
Comparing Criticality vs. Criticality - Microsoft Internet Explorer

File Edit View Favorites Tools Help

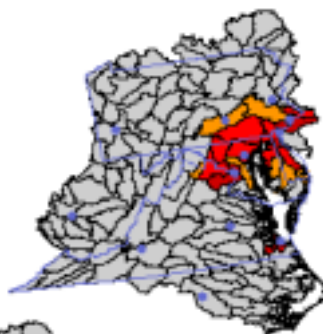
Comparing Criticality Analysis to Criticality Analysis - Future



Criticality Analysis

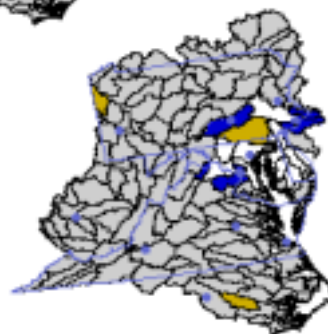


Criticality Analysis - Future



Watershed Summary
Method Comparison

- LHS better
- Same
- RHS better



Difference Map

Graph comparing integration method - Criticality - to
integration method 2 - Criticality

ical Summaries

ht Variables

are Variables

Data for first map Lower density scenario

First map groups Water

First map data Forest land cover along streams

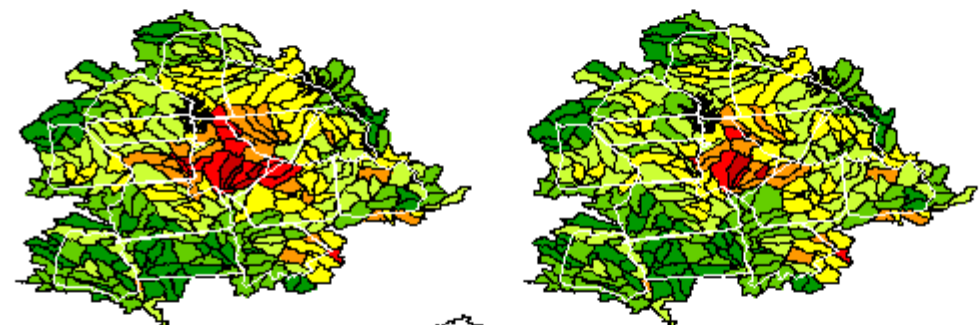
Data for second map Higher density scenario

Second map groups Water

Second map data Forest land cover along streams

Construct Maps

Lower density scenario-Forest land cover along streams Higher density scenario-Forest land cover al



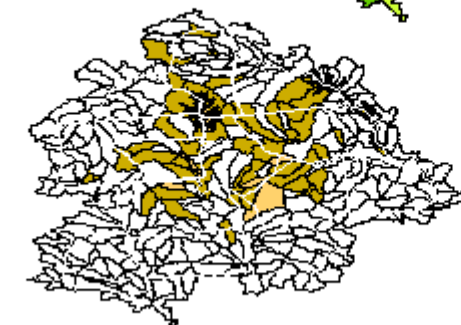
Watershed Summary
Method Comparison

LHS +2 groups

LHS +1 group

Same

RHS -1 group



ical Summaries

ht Variables

are Variables

Data for first map Lower density scenario

First map groups Water

First map data Dissolved phosphorus

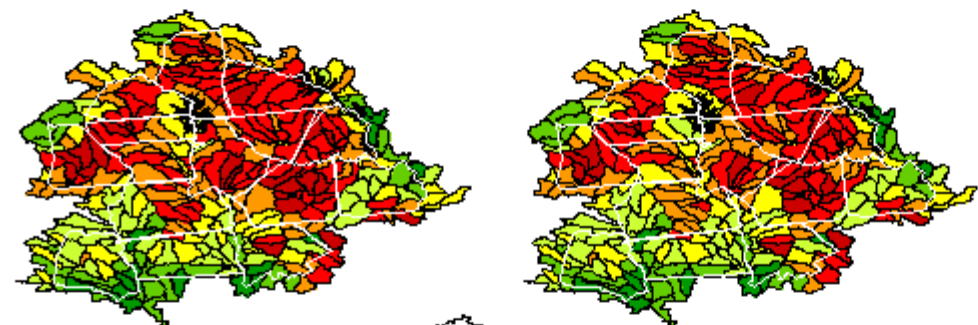
Data for second map Higher density scenario

Second map groups Water

Second map data Dissolved phosphorus

Construct Maps

Lower density scenario-Dissolved phosphorus (kg/ha/yr)Higher density scenario-Dissolved phosphorus



Watershed Summary
Method Comparison

LHS +2 groups

LHS +1 group

Same

RHS -1 group



ical Summaries

ht Variables

are Variables

Data for first map Lower density scenario

First map groups Water

First map data Forest land cover along streams

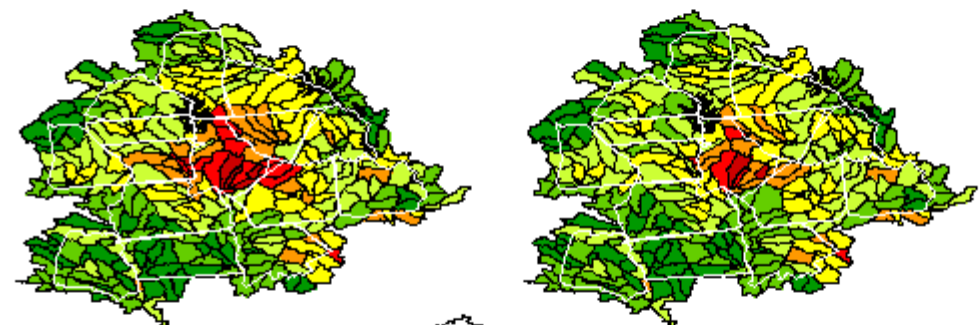
Data for second map Higher density scenario

Second map groups Water

Second map data Forest land cover along streams

Construct Maps

Lower density scenario-Forest land cover along streams Higher density scenario-Forest land cover al



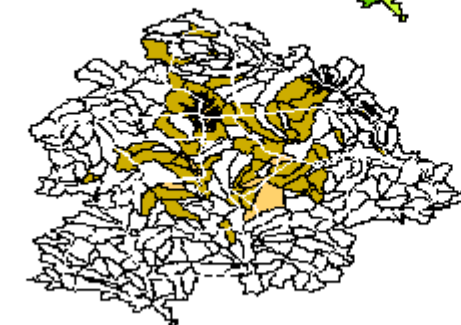
Watershed Summary
Method Comparison

LHS +2 groups

LHS +1 group

Same

RHS -1 group



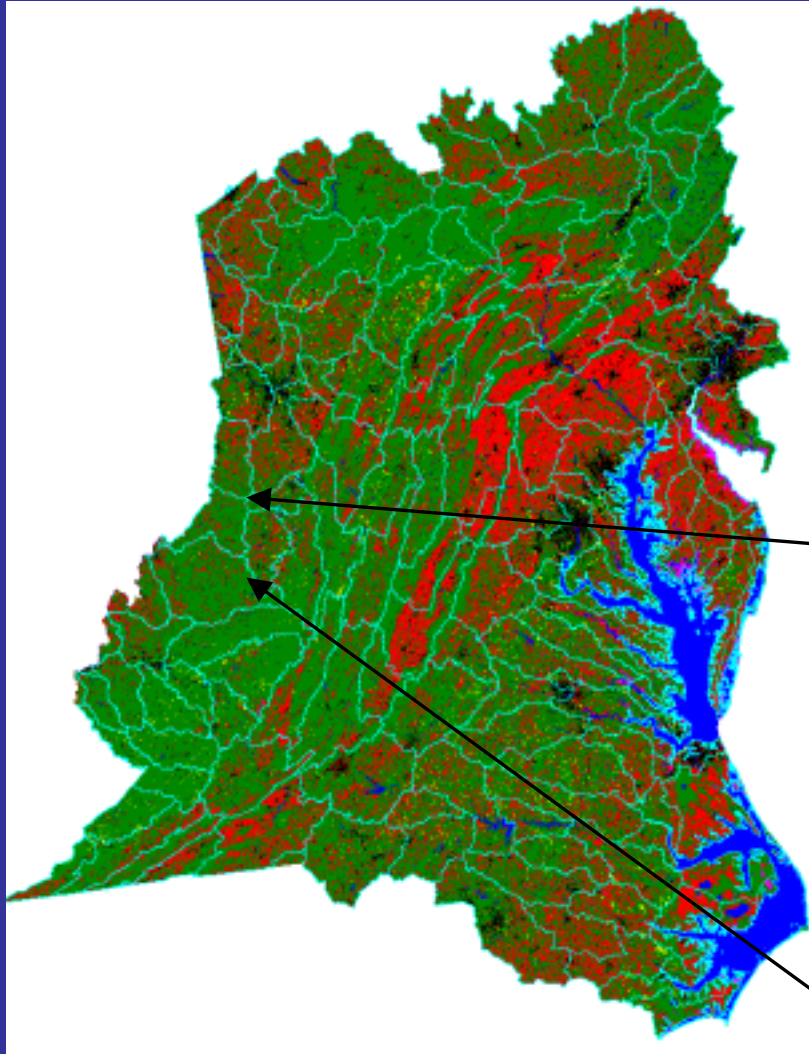
Current Uses of Approaches and Tools

- R3 – Strategic Planning – Vulnerable populations, Watershed health, Responsible development - outreach and partnerships
- MD DNR, PA DEP, Baltimore County – outreach, identification of priority areas for protection, alternative scenarios of development
- SEQL project – alternative scenarios of development, opportunities for cross-media trading, focus on quality of life

Next Steps: Applying ReVA Approach and Information to Decision-making

- Evaluating alternative “Smart Growth” strategies
- Identifying where to set aside lands for conservation
- Assessing impacts of alternative incentives for pollution prevention
- Investigating solutions for “cross boundary” issues associated with air and water quality (e.g. cross-media trading)
- Estimating impacts of new road development (water quality, air quality, quality of life)
- Tracking progress/performance

ReVA's Environmental Decision Toolkit: turning data into information



- *Allows synthesis of existing data*
- *Provides assessment capabilities to address multiple criteria*
- *Allows flexibility in setting priorities*

